MECHANICS' MAGAZINE.

AND

JOURNAL OF THE MECHANICS' INSTITUTE.

WHOLE No. 211 FRIDAY, APRIL 28, 1837. [MONTHLY, 53.

TRANSACTIONS OF THE INSTITUTION OF CIVIL ENGINEERS.

AN ACCOUNT OF THE NEW OR GROSVENOR BRIDGE OVER THE RIVER DEE AT CHESTER.

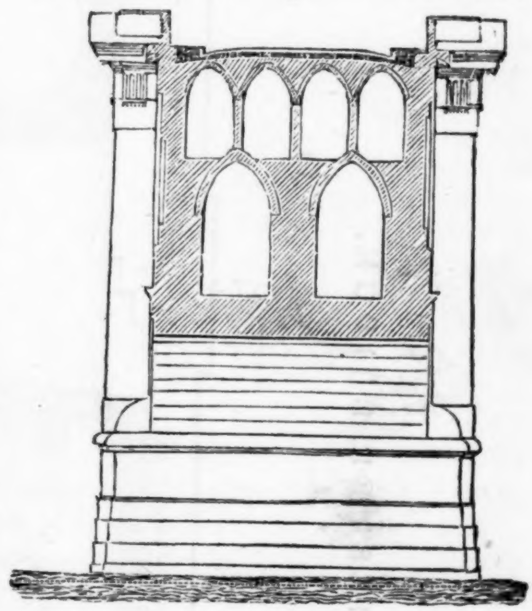
[The drawings from which the engravings of this bridge (plates Nos. VII. and VIII.) have been made were furnished by Mr. John B. Hartley, son of the engineer under whose direction the edifice was built, and the following account has been derived from a letter from him to the President, accompanying the plans, and other original communications in the possession of the Institution, and partly from the minutes of conversation at several meetings when Mr. Trubshaw, the contractor for the work, was present*, while such other trustworthy sources of information as were accessible have also been referred to. The statements, so far as they go, rest therefore on good authority, but the Council cannot help regretting that they are unable on this occasion to present a connected account of the work worthy of its magnitude, directly from the pen of some one of the gentlemen engaged in its construction.

Though the site of the new bridge is quite apart from that of the old one, and the latter exists as before with the exception of being no longer the leading thoroughfare, a short notice of the ancient structure, as supplied by antiquarian writers, has not been considered altogether out of place.]

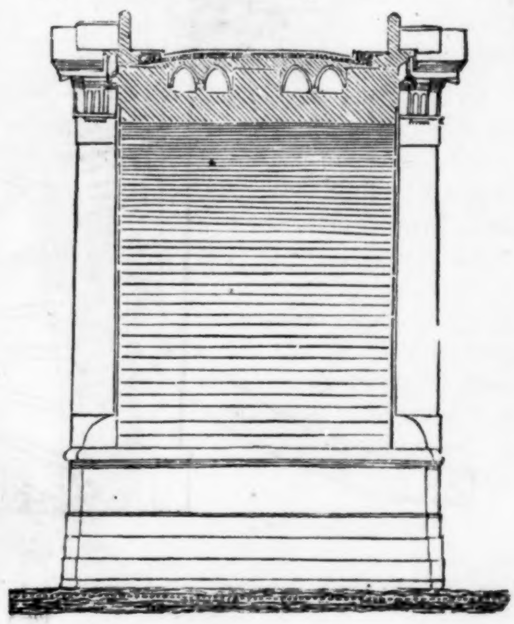
The old bridge over the Dee at Chester extends from the city to a suburb on the opposite side of the river named Handbridge. The first notice of a bridge in this place occurs in the thirteenth century, during which it is recorded to have fallen down or been carried away twice. Those structures were most probably of timber, but on the second accident alluded to a stone erection seems to have been substituted at the cost

Plate 7.

Cross Section through the line A. B.

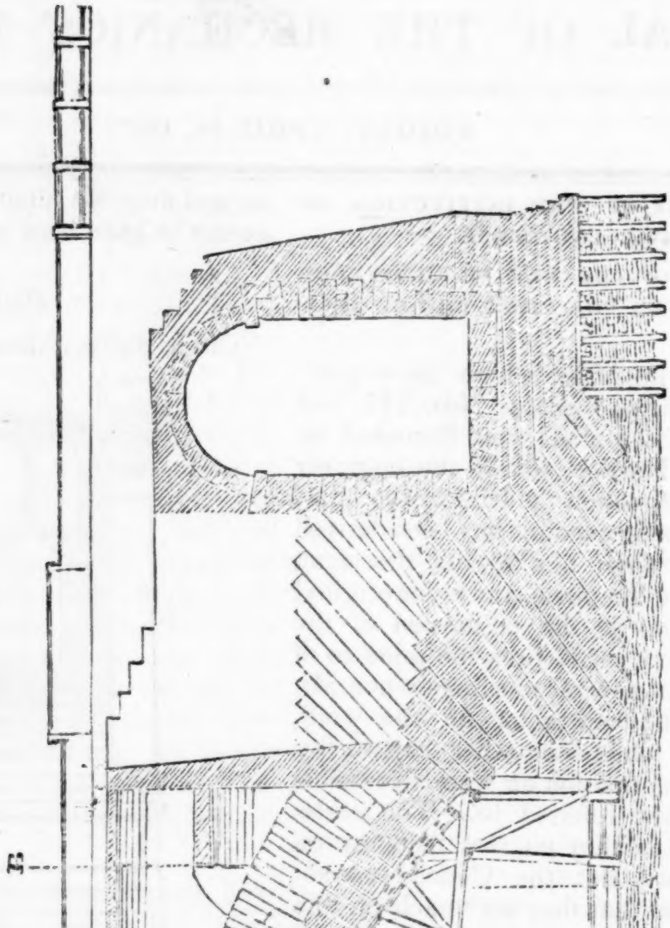


Cross Section through the Crown.



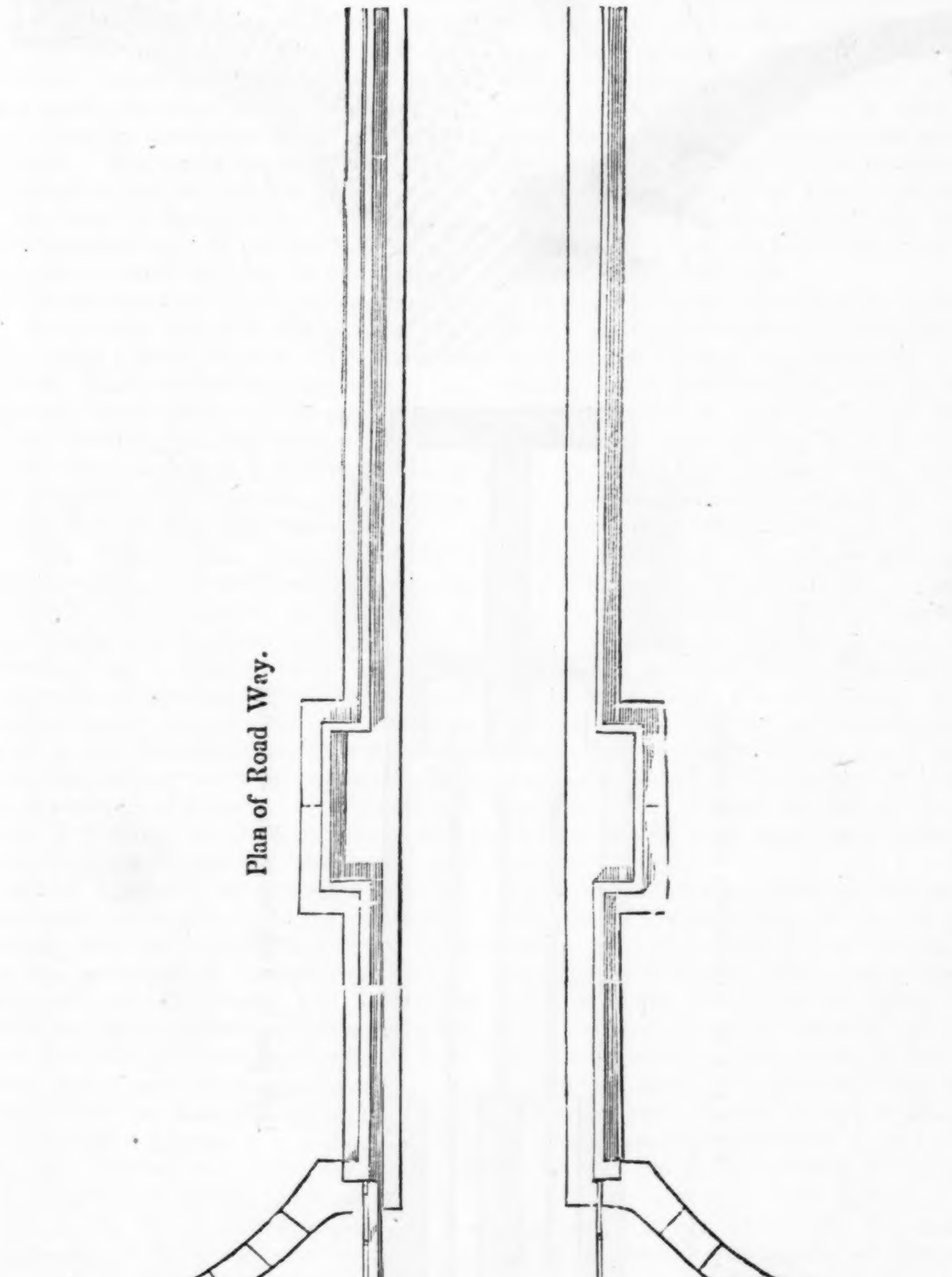
* Orig. Commun. Vol. IV. No. 9, and Vol. V. No. 16; Min. of Convers. Vol. V. Nos. 8, 9, and 13.

Plate 7.

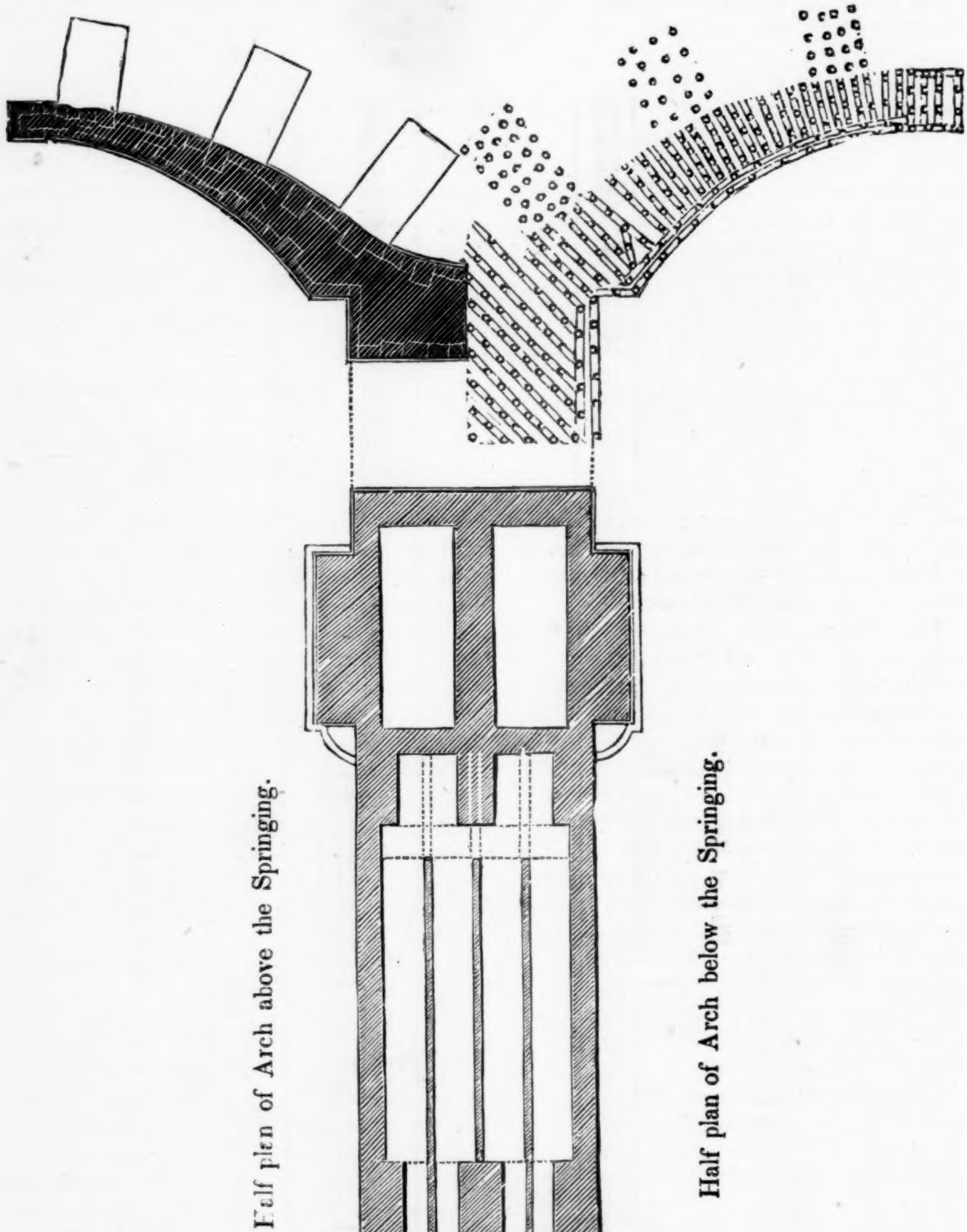


CHESTER BRIDGE.

Half Section showing the centre.



Plan of Road Way.



Half plan of Arch above the Springing.

Half plan of Arch below the Springing.

of the citizens: this was in 1280, and it does not appear that the bridge has been entirely rebuilt since, though it is mentioned that part next Handbridge was "made new" in the year 1500. The two arches on this side are plainly of later build than the rest; one of them is in form a segment of a circle, the other is very slightly pointed, while the remaining arches are pointed Gothic. The whole has been repaired and widened within the last few years.

As usual in former days, Chester Bridge was provided with its gates, which remained until towards the end of last century. Each extremity of the bridge was guarded in this manner, and over the gate next the city stood a tower, named "Tyrer's Tower," for raising water from the wheels under some of the arches for the supply of the town: the tower no longer exists, and there is now only one gate, a modern edifice, on the English side of the river, but the water works and the weir still remain.

The bridge, thus irregular alike in workmanship, form and dimension, consists of seven arches supported on huge piers or buttresses, and has been aptly and pithily described as "a long fabric of red stone, extremely dangerous and unsightly, and approached by avenues on the Chester as well as the Handbridge side, to which the same epithet may be safely applied."* The inconvenience of a steep and twisting passage of this kind on the main communication between Wales and the centre and north of England, became more felt every day amid the rapidly growing intercourse arising from the improvement of the roads in the principality, particularly that to Bangor and Holyhead, and at length brought about a conviction of the necessity of a new bridge. It was many years, however, before any active measures were taken to carry so desirable an object into effect, nearly a quarter of a century having elapsed between the period when the late Mr. Harrison of Chester projected the structure on the site it now occupies, and the beginning of the work; and by this time, from advanced age and declining health, the superintendence of its execution required too much exertion for the strength of that most respectable practitioner, whose works have added so much to the architectural embellishment of his picturesque native city. Under these circumstances Mr. Hartley of Liverpool was applied to by the commissioners to undertake the management, which he consented to do on the condition that no alteration should be made from Mr. Harrison's external design, but that the interior and all practical points should be left entirely to him. It may be proper to add that Mr Harrison had given two elevations, one having the abutments ornamented with Grecian Doric columns, the other having a plain niche with a pannel over it, and that the latter was adopted by Mr. Hartley's advice.

The new bridge is situated about a quarter of a mile to the west of or lower down the river than the old one, stretching from the rock below Chester Castle towards the village of Overlegh, with a boldness that appears still more striking if the view be from the low ancient bridge. The valley of the Dee here skirts close round the city, the ground next which rises rapidly, and the road is carried with a slight fall from the castle gate on an embankment, which, after ascending gently over the bridge, is continued across the broader plain on the other side of the river, until it falls into the Flintshire road from the old bridge. The harbor is below the site, but vessels occasionally pass above the bridge, which from its great height offers no obstruction to navigation. The flow of the tide so far up the river is not more than twelve feet in ordinary springs.

The abutments are founded on the solid rock, except the back part of that on the north or city side, where, a fault occurring from the rock dipping down almost vertically as shown on the section, piling became necessary; and so soft was the material with which the fissure was filled, (a kind of quagmire or quicksand,) that the piles went down five or six feet at a blow for a considerable part of their depth. On the head of the piling a floor of stone was laid and the abutment built upon it. In consequence of the defect in the foundation just mentioned it was considered prudent, with a view to keep the lateral thrust of the arch within the limit of the rock, to make the springing a foot lower and the crown as much higher than was at first intended, and this was the only deviation from the original design that took place in the work.

The arch is a segment of a circle of 140

* Ormerod's Cheshire, Vol. I. p. 285.

feet radius, the span or chord being 200 feet and the rise or versed sine 42 feet. The archstones are 4 feet deep at the crown, and increase to 6 feet at the springing, but from the mode followed in laying the masonry, it will be seen that the principle of the arch is carried through the abutments, even down to the foundations, the radiating joints giving place to horizontal ones only in what is comparatively superstructure.

To prevent flushing near the haunches and rectify any tendency to change of form in the arch on the removal of the centre, the first course above the springers was laid upon a wedge of lead 1½ inch thick on the face and running out to nothing at the extremity of the bed, and strips of sheet lead eight or nine inches wide were also introduced in the joints on each side, up to where the point of pressure was considered to change its position from the front to the back of the archstones, or in fact in the present case over about two-thirds of the whole soffit. This disposition remained unaltered until the easing of the centre let the whole of the arch settle on the lead, which from its yielding nature then caused the pressure to be spread evenly over the whole of the bed of each course, and thereby prevented drafts or openings at the back of the archstone joints; the wedge-piece at the springing also acting by way of adjustment, and counteracting the inclination of the arch in coming to its bearing when the centre is struck to throw an undue weight on the intrados of the springing course. Judging from the soundness of the archstones throughout, this plan seems to have answered fully the end sought, the weight having been received so uniformly and gradually on all points, that not the slightest appearance of *spaulching* or cracking is perceptible in the work of the great arch.

In setting the keystones three thin strips of lead were first hung down on each of the stones between which they were to be inserted, and the keystone being then besmeared with a thin greasy putty made of white lead and oil, was driven down with a small pile-engine, the lead acting as a slide and preventing grating until the stone was quite home.

The mode in which the spandrils were made up internally, by tiers of pointed arches with flag-stones or landings at top to carry the road material, will be seen by a glance at the cross section on plate No. VIII; and indeed beyond what has been already stated, and the materials used, which are now to be described, with the mode of dressing them, there does not seem much of importance as regards the construction of the permanent part of the work which an inspection of the plans will not readily supply.

The river face of the abutments up to the springing, and the first two courses of archstones above, are of granite; the key-course with one on each side of it and the quoins all through the arch are of the limestone known as Anglesea marble, and the rest of the work, including all the other archstones, almost entirely of the sandstone of the country. The granite was brought from Craignair near Castle-Douglas in Kirkcudbrightshire, the limestone partly from Anglesea and partly from the similar quarries of Wagbur near Burton in Kendale, and the other stone for the outside works from Manley near Northwich and Peckforton near Nantwich in Cheshire, the quarries of both which places produce a superior kind of the new red sandstones. The principal part of the banking is of a similar sandstone, found adjacent to the site of the bridge. The mortar used was made from the lime found in the neighborhood, mixed with twice its bulk of sand.

The external faces of the bridge and abutments, with the cornices, parapets and dressings, are neatly tooled; the land-arches and wings slightly chamfered in the joints and then scappled off, so as to have a rougher and more rustic appearance. The archstones of the main arch are also chamfered in the soffit joints, two inches on each arris.

The centre on which the stupendous arch of Chester new bridge was raised, and which is stated by Mr. Hartley to have been exclusively designed by Mr. Trubshaw, claims a detailed notice, from the novelty of the principle it was formed on, the efficiency with which it did its work, and the economy that attended its use. The centre consisted of six ribs in width, and the span of the arch was divided into four spaces by means of three nearly equidistant piers of stone built in the river, from which the timbers spread *fan-like* towards the soffit, so as to take their load *endwise*. The lower extremities of these radiating beams rested in cast iron shoe-plates on the tops of the piers, and the

upper ends were bound together by two thicknesses of 4 inch planking bending round, as nearly as they could be made, in the true curve of the arch. On the rim thus formed the *lagging* or covering, which was 4½ inches thick, was supported over each rib by a pair of folding wedges, 15 or 18 inches long by 10 or 12 inches broad and tapering about 1½ inch;—for every course of arch-stones in the bridge there were therefore six pairs of striking wedges. The horizontal timber of the centre was only 13 inches deep, and the six ribs were tied together transversely near the top by thorough bolts of inch iron. but with a view not to weaken and injure the timber more than was absolutely necessary, the least possible of iron was used.

From this description and an examination of the drawing it will be observed, that the centre differs essentially from those that have been used elsewhere. At first sight it reminds one of that employed by Smeaton in building Banff bridge, but the likeness is only apparent. Each rib of the latter is a complete connected frame from pier to pier, though supported intermediately, and is capable of being eased only as one mass by the folding wedges which are placed under and carry it; whereas in the Chester centre each rib is composed of four distinct and independent parts, and carries the wedges on its outer rim instead of being borne by them, so that it can be struck gradually, being made tight at one place and slackened at another, according to the symptoms shown by the arch as its support is removed and the stonework comes to its bearing. Mr. Trubshaw's principle is, therefore, in a few words, to arrange the timber so as to have the strain all in a vertical direction, doing away with the necessity of much horizontal tying, which from its sinking he considers apt to derange the framing, and to ease immediately under the covering instead of under the sill of the centre; and with this construction he would strike a centre soon after the arch was finished, while the mortar was yet as it were a paste, easing a little at first and then giving some time for the joints to accommodate themselves, and so proceeding. His method of striking is to keep up the crown and let the haunches down, and though this has a tendency to press the keystone up, he states that he has found a greater and more usual difficulty to be in managing an arch after the key was lowered, as it must be at once and beyond recall with centres of the usual make.

The centre was of fir, and with the exception of the parts already mentioned as otherwise, was composed entirely of whole and half timbers;—pieces from 22 to 36 feet long were not bored with more than one hole, and it of small size, so that, the material being sound when taken out, the whole cost to the contractor was only about £500, an amount which, even allowing for the advantage derived from the accidental circumstance of a quantity of seasoned wood being opportunely required for a public work in the neighbourhood, must still be considered a very low price for a structure requiring 10,000 cubic feet of timber. That the expectations of the projector were fulfilled in other respects also, is proved by the circumstance of half the arch being turned before the centre was finished, while the fact that on its removal the crown sank only from 2½ to 2⅝ inches, the joints remaining perfectly close and no derangement of form being perceptible, attests the skill and care at once of the carpenter and the mason.

In reference to the temporary works, it seems necessary only further to mention that the archstones were carried to their places by the traversing machine now usually adopted for such purposes, which, though old in principle, it is believed assumed its present form in the hands of the late Mr. Rennie, as a means of working the diving bell in his operations at Plymouth. Of the contrivance, though it scarcely requires description in the present day, it may be shortly said, that it consists in suspending the body to be moved to a carriage travelling on a railway fixed on a frame of timber, which frame is itself moved in like manner on a similar railway under and at right angles to it, so that the carriage has a double motion and can be brought over any point within the range of the frames to deposit its load. In the present case the *inferior* railway extended from abutment to abutment, resting on the intermediate piers, and on it travelled two transverse frames of from 45 to 50 feet span, so as to embrace the whole width of the arch; and there being thus a carriage at each end of the bridge, the setting of the archstones did not consume much time.

To be continued.

DOMESTIC ECONOMY.

Hang or Dried Beef.—Take eight ounces of common salt, two ounces of saltpetre, made into brine. This quantity to be applied to ten lbs. of Beef. It should lay in the brine four weeks; and then be hung up in the kitchen or some warm apartment to become dry. In order to preserve it from insects in summer, it should be tied up in a linen cloth.

The above receipt was given me by an excellent farmer and manager in Massachusetts; and the beef *cured by it* was of the finest description. H. C.

Salt or Corned Beef.—One peck of coarse salt, four ounces of saltpetre, one and a half pound of coarse brown sugar. Add to the above ingredients, four gallons of spring water; boil and skim it until it is quite clear; when cold it is fit for use. The meat, either beef or pork, should be salted a few hours before it is put in the pickle. Hams and Tongues are very fine cured with the same pickle.

The above receipt is called Admiral Pococke's pickle, and is much approved and generally used in the British Navy. I have successfully tested its value. H. C.

Household Soap.—Put fourteen lbs. of Potashes to twenty lbs. of good grease for one barrel. Put the potashes into two pails of water over night; put the grease into a kettle and pour the potashes over it; let it boil moderately, filling it up with cold water until it thickens; then put it into the barrel, and fill it up, (a pail full at a time) stirring it about until the barrel is full.

Soap Making.—The subjoined is from a friend as well skilled in all matters of domestic economy and household management, as any one I have ever known.

H. C.

The last Soap I made, we used 20 lbs. of potashes and 25 lbs. of grease to a barrel; and it made excellent soap. Success much depends on having the best quality of potashes. I have a set-kettle in which I dissolved the potashes and put it into the trough in which we keep the soap; then melt the grease and put to it, the mass is then hot; having conveniences for heating the water, I have generally filled it up keeping the whole hot; by this means the ingredients incorporate quickly; and I have had but little to do after the first day. But I do not add the whole of the water at once. I prefer doing it by degrees, and stirring well at each time. There will be no difficulty, if you have good materials; and get them thoroughly incorporated. I have no doubt it may be effected as surely with cold water after the ingredients are mixed and put together; but it will require longer time and more labor to stir it. I have been troubled a little once or twice by getting weak potashes; and have been obliged to add more, but have always succeeded in the end.—Once I recollect I put more potashes than usual, and it was too powerful. I then added more grease and water and reduced it; the above proportion, I think, is about right, if the materials are good; if the potashes should prove otherwise, more may be added.—[Brookline.] B. G.

Cooking Potatoes.—This is no inconsiderable art; and I have some suspicion that Cobbett's ignorance of the best way of doing this may have been one reason of his antipathy to the use of this esculent. The direction given by one writer is, never to put your potatoes into cold but boiling water; and keep it boiling until the potatoes are done or sufficiently boiled; then pour off the water as soon as possible; if a little salt be thrown into the water when boiling, the better." We will add a better mode than this, which has been so thoroughly and successfully tested, that we believe it cannot fail to be approved: Select the potatoes you design for dinner the day previous; pare them and throw them into cold water and let them stand three or four hours; then, at a proper time before dinner, put them into boiling water; and when they have sufficiently boiled, turn off all the water, leave off the cover and hang them over the fire to dry. When the steam has passed off they will then be in the best possible condition for eating. By this mode, potatoes even of a watery and inferior quality, become mealy and good. H. C.

MECHANICS' INSTITUTE.

PROCEEDINGS OF THE MECHANICS INSTITUTE OF THE CITY OF NEW-YORK.

This Institution having entered into an arrangement with the Editors of the Mechanics' Magazine, of the city of New-York, to publish their proceedings, will hereafter furnish regularly for publication such matter relative to the Institute, to science and to the arts, as may be considered worthy of public notice.

The following is a list of officers for 1837—38.

George Bruce, President.

John M. Dodd, 1st Vice President.

Henry Cunningham, 2d Vice President.

George L. Spencer, Rec. Secretary.

Leonard D. Gale, Cor. Secretary.

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Sylvanus S. Ward,	John Bidley,
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Peter Wemmel,	Jacob S. Anderson,
Abraham Storms,	William Ballard,
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The above list of officers and Directors which are elected annually in April, constitute a Board of Directors for transacting the business of the Institute.

The Board is divided into five Committees, as follows. A Committee of Finance; one on Publication and Lectures ; one on Science, Arts, and Scientific Meetings ; one on the Library and Reading-Room; and one no Donations.

The Institute holds its regular monthly meetings for transacting its financial and other ordinary business, at the Institute Rooms, City Hall, Basement story, the first Tuesday in each month; the remaining Tuesday evenings of the month are taken up by the Scientific Meetings, at which lectures are given, Essays read or experiments made on science and its application to the useful arts.

The scientific meetings have already been established nearly six months, and the uniformly full attendance manifest the interest they have excited in the minds of the members. The committee of Publication take this opportunity to call the attention of such new members as have not yet availed themselves of the privileges of the Institute to the useful information communicated at the scientific meetings.

Proceedings of the Scientific Meetings continued from December 1836.

December 13th. James Thomas, Esq., gave a lecture on the various methods in use for taking the specific gravity of liquids and solids—exhibiting the facility and accuracy with which the specific gravity may be taken, by means of a common grocers scales, by operating on larger quantities than are generally used by experiments. The lecture was illustrated with a variety of experiments.

December 20th. Dr. Gale gave a lecture on the relative permanency of materials used for buildings, showing the different effects of different climates, in wearing down, and otherwise reducing the monuments of art in different countries. After which James Frost, Esq., made some appropriate remarks on the comparative methods of building in England, and in the United States, and especially called the attention of the members to the manner in

which the house of the recent firm of the Joseph's in this city was constructed, showing that from the manner in which the arches were put up, the expansion and contraction by heat and cold would soon cause the walls to give way, an event which has since proved true.

December 27th. Dr. Gale gave a lecture on Geology, on the indications of coal, and in what countries and formations it may be sought with probability of success.

January 10th, 1837. Dr. Feuchtwanger gave a lecture on Precious Stones, illustrated by a great variety of specimens.

17th. Dr. Wallace gave a lecture on the method of silvering looking glasses.

24th. J. M. Dodd, Esq., gave a lecture, (the first of a series) on the history of building, commencing with the earliest history of man and extending to the founding of the Roman Empire.

31st. J. M. Dodd, Esq., gave his second lecture on the history of building—in which the history was continued to the decline of the Roman Empire.

February 14th. Henry Durell, Esq., gave a lecture on coloring and marbling paper, in which the whole process was exhibited experimentally, and a considerable variety of specimens were manufactured in the presence of the members.

21st. Andrew Boardman, Esq., gave a lecture on the Progress of Improvement in Society.

28th. T. J. Carmichael, Esq., gave a lecture on the methods adopted by order of the Water Commissioners for supplying this city with water which work is now in progress.

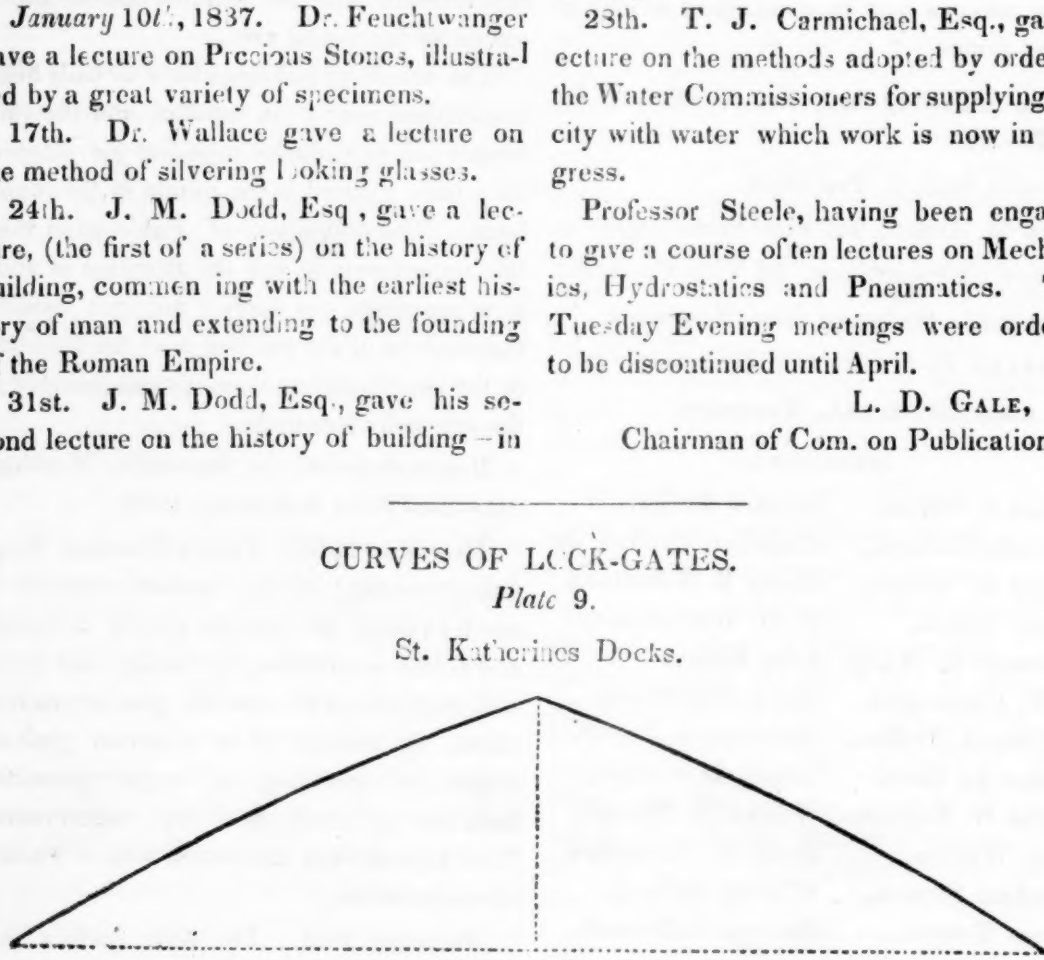
Professor Steele, having been engaged to give a course of ten lectures on Mechanics, Hydrostatics and Pneumatics. The Tuesday Evening meetings were ordered to be discontinued until April.

L. D. Gale,
Chairman of Com. on Publication.

CURVES OF LOCK-GATES.

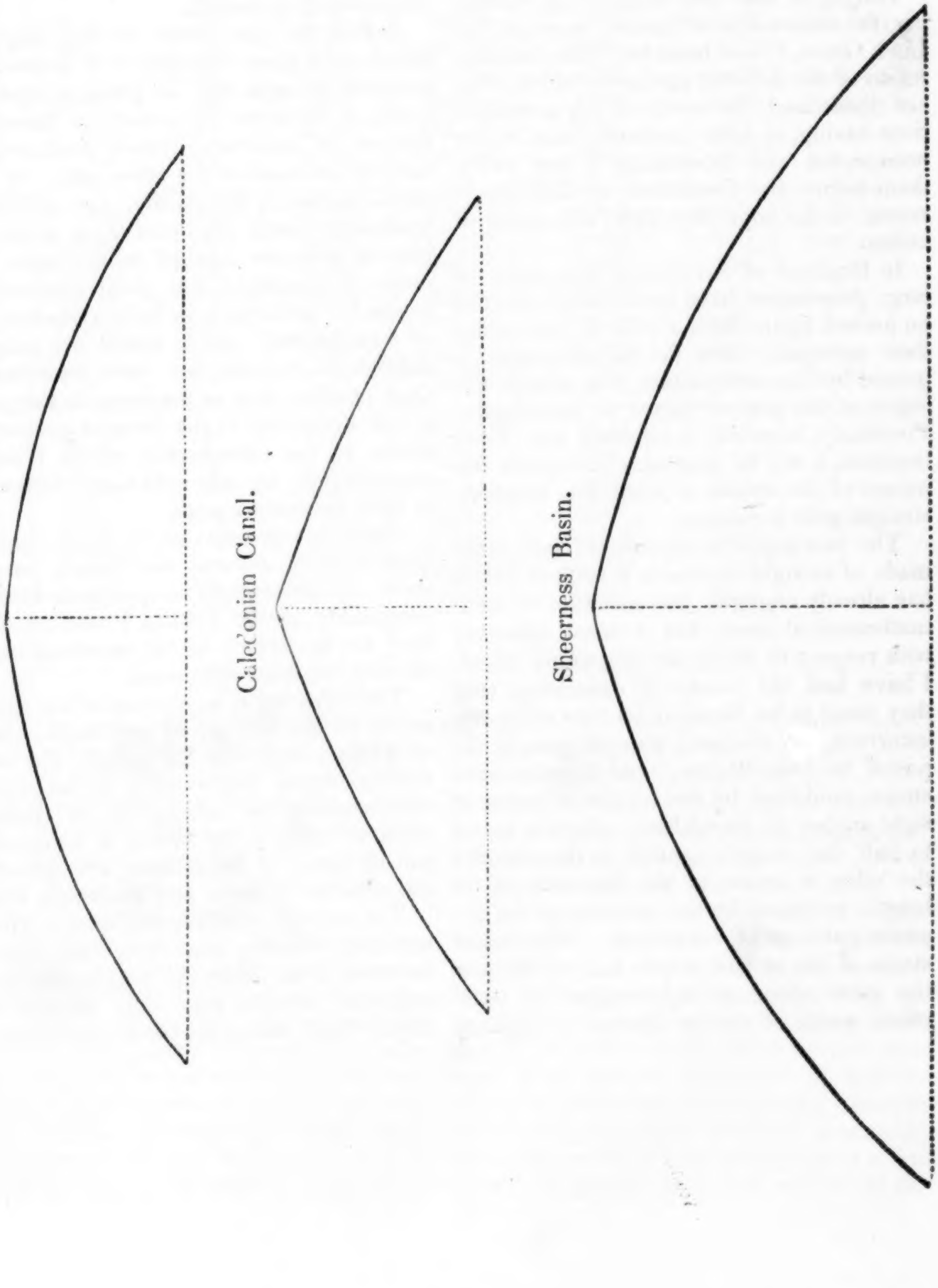
Plate 9.

St. Katherines Docks.



London Docks.

West India Docks.

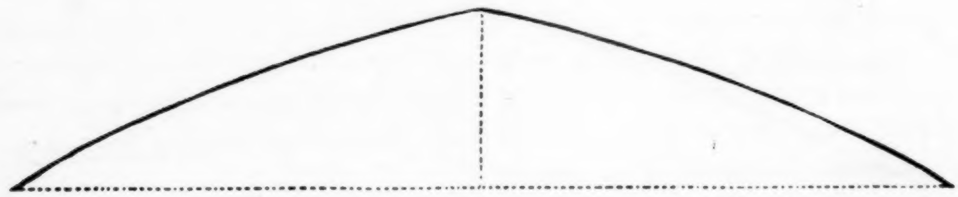


Proposed Curves.

Caledonian Canal.

Sheerness Basin.

Dundee Docks.



ON THE STRAIN TO WHICH LOCK GATES ARE SUBJECTED. BY PETER W. BARLOW, CIVIL ENGINEER.

Having of late been engaged in estimating the dimensions of timber required for Lock Gates, I have been led to the consideration of the different strains to which they are liable, and the results of my investigations having, in some instances, been rather unexpected and interesting, I beg to lay them before the Institution of Civil Engineers, in the hope that they will prove of utility.

In England of late years, lock gates of large dimensions have been constructed of an arched figure, with a view to increasing their strength; how far an advantage is gained by this construction, it is chiefly the object of the present paper to investigate. Previously, however, to entering into these inquiries, it will be necessary to explain the nature of the strains to which the common straight gate is exposed.

The best angle for the sally of lock gates made of straight timber is a subject which has already engaged the attention of some mathematical men, but I must observe, with respect to those investigations which I have had the means of examining, that they seem to be founded on data evidently incorrect. A common straight gate is exposed to two strains; one a transverse strain, produced by the weight of water at right angles to its surface, which is equal to half the weight applied in the middle; the other a strain in the direction of its length, produced by the pressure of the opposite gate upon its extremity. This latter strain, if the salient angle was of 45°, or the gates stood at right angles to each other, would of course amount to half the weight on the opposite gate, so that at this angle a lock gate has, in addition to the transverse strain, an equal strain in the direction of its length.

Before we can arrive at the angle at which, with given dimensions of timber, the greatest strength will be given to a pair of gates, it becomes necessary to know the amount of transverse strain produced by the end pressure of the other gate; or in a beam loaded in the middle, the additional transverse strain produced by a given degree of pressure applied at the ends. In order to ascertain this point precisely, it would be necessary to have a distinct set of experiments, which would not only be difficult to execute, but very uncertain in their results; and as precision in this point is not necessary to the present question, I think, by the examination of M. Girard's experiments, we may arrive at it sufficiently near for our purpose.

These experiments were made upon a large scale by order of the French government, and although there appears to be some rregularity in the results, I have no doubt they are as correct as the uncertain nature of such inquiries will permit.

The following is an abstract of his experiments on the strength of oak baulks loaded at the end, and with the weight the same timbers would bear loaded in the middle, calculated by the rules given in Barlow's work on timber; by which a comparison can be made of the relative strength when subjected to a direct and transverse strain.

The timbers experimented upon by Girard were not in every case completely broken, but there is no doubt the weight they were subjected to was very little short of that which would have completed the fracture.

TABLE I.—Abstract of GIRARD'S EXPERIMENTS on the Strength of Timber loaded on the End.

No. of experiments.	DIMENSIONS OF THE TIMBER.			Weight in pounds the beam bore applied to the extremity.	Weight in pounds the same beam would bear loaded transversely	Ratio.	REMARKS.
	Length.	Breadth.	Thickness.				
	FEET.	INCHES	INCHES.				
1	8	6.21	5.03	93616	8598	·092	
2	8	6.39	4.17	94018	6078	·064	Broken.
3	8	6.21	3.99	69165	5390	·078	
4	8	5.23	3.89	50526	4325	·085	Broken.
5	8.628	5.15	4.17	50608	4900	·097	Broken.
6	7.549	6.02	5.15	115359	9980	·087	
7	7.549	6.21	5.05	103799	9909	·095	
8	7.549	6.12	4.085	73095	6396	·087	Broken.
9	7.549	6.21	3.99	63177	6336	·100	Broken.
10	7.549	4.96	3.99	44857	4924	·109	
11	6.471	6.12	5.24	87494	12366	·141	
12	6.471	6.21	5.15	87481	12013	·136	
13	6.471	6.21	3.99	87079	7392	·085	
14	6·471	6.30	3.99	72823	7313	·100	Broken.
15	6.471	5.24	4.17	103622	6525	·063	
16	6.471	5.05	4.25	82261	6674	·081	
17	7.549	6.21	4.25	87443	7022	·080	
18	8.628	6.21	5.32	82332	9607	·116	Broken.
19	8.628	6.21	5.15	103863	8993	·087	
20	8.628	7.37	6.21	137966	15584	·113	
21	8.628	7.45	6.21	137866	15764	·114	
					Mean	·996	

It thus appears that the force required to break a timber in the direction of its length, is about ten times that which would break it if it applied transversely at the middle; from which I infer that the strain in the direction of the gate produced by the pressure of the opposite one, is equal to an additional strain of one-tenth applied transversely.

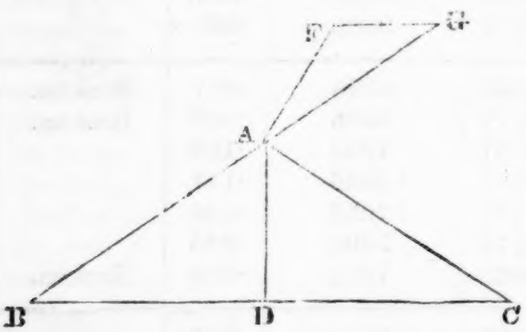
A difference exists in the comparison made in the preceding Table and in the case of lock gates, which it is necessary to make some remarks upon; viz., that a lock gate has a transverse pressure acting in addition to that produced by the other gate, so that the end pressure is exerted upon it after it is already deflected by a transverse strain which is of course not the case in the comparison made in the Table. How far this may effect the question, or how much greater effect the compressive force may have in consequence of the beam being already deflected, it is very difficult to determine, but from an examination of the subject, I am induced to think that the deflection is so small as very slightly to increase the effect of the end pressure.

The amount of the effect will of course depend upon the degree of deflection the beam has sustained from the transverse pressure, and if it amounted to a quantity exceeding one-twentieth of the length, (which would make the lever by which the end pressure acted exceed one-tenth of that by which the transverse strain acted,) a greater effect than one-tenth would be produced; but as the ordinary load which timber is expected to sustain, does not produce at the

utmost a deflection exceeding one hundredth part of the length, I cannot conceive the transverse strain above named materially to alter the comparison, and I have accordingly, in the following investigation, assumed one-tenth as the amount of additional strain produced by the end pressure of the opposite gate.

It now becomes necessary to get an expression for the amount of the strains above mentioned at any angle of salience, which is arrived at in the following manner :—

Let AB, AC, represent the two gates, meeting at the point A ; draw the line AD from the point A perpendicular to BC, and let BD, which represents half the breadth of the lock, $= l$, also



let the pressure of water upon the length l of the gate be indicated by w and the angle $ABD = \varphi$.

Then the length of the AB and any angle φ will be expressed by $l \sec \varphi$

and the pressure upon it by $w \sec \varphi$

The transverse strain produced by this pressure on the centre of the beam at the same angle will be $\frac{1}{2} w \sec \varphi$

It now remains to find the amount of compression in the direction of the gate, produced by the opposite gate.

Let AF represent the force or tendency of the gate AC to turn upon the point C, which is of course equal to half the weight upon the gate A C,

$$\text{or} = \tfrac{1}{2} w \sec \varphi$$

The force may be resolved into AG, FG, the one GF is supported by an equal and opposite force in the gate AB, and the other will represent the force in the direction of the gate, the expression for which may be found as follows ;

as sine $\angle$ AGF : AF : : sine $\angle$ AFG : AG

$$\text{or sine } \varphi : \tfrac{1}{2}w \sec \varphi : : \cos \varphi : \tfrac{1}{2}w \sec \varphi$$

$$\frac{\cos \varphi}{\text{sine } \varphi} = \tfrac{1}{2} \operatorname{cosec} \varphi$$

The whole amount of transverse strain at any angle φ will therefore be represented by the expression,

$$\tfrac{1}{2}w \sec \varphi + \tfrac{1}{20} w \operatorname{cosec} \varphi$$

from which we may readily obtain the angle at which the strain is a minimum as follows ;

$$\sec + \varphi + \operatorname{cosec} \varphi = \min$$

$$\text{or } \tan \varphi \sec \varphi \, d\varphi -- + \cot \varphi \operatorname{cosec} \varphi \, d\varphi = 0$$

$$\text{whence } \tan^2 \varphi = \tfrac{1}{10} \operatorname{cotan} \varphi$$

$$\text{and } \tan^3 \varphi = \tfrac{1}{10}$$

$$\tan \varphi = \sqrt[3]{\tfrac{1}{10}} = \tfrac{1}{10} \sqrt[3]{100} = .4341$$

$$= \tan \angle 24° \, 54'$$

The salient angle of a pair of oak gates, when the strain is a minimum, is therefore 24° 54′

In the question of the best angle for lock-gates, it becomes necessary to consider that the length of the gate also varies as the secant of the angle φ. The angle 24° 54′ is therefore not that at which, with a given section of timber, the greatest strength will be obtained ; for although the strain is the least at this angle, yet the gates, by their greater length, are less able to resist it than at some intermediate angle, when the strain is slightly increased. The expression now becomes

$$\sec^2 \varphi + \tfrac{1}{10} \sec \varphi \operatorname{cosec} \varphi = \min$$

$$2 \sec^2 \varphi \tan \varphi \, d\varphi + \tfrac{1}{10} (\tan \varphi \sec \varphi \operatorname{cosec} \varphi — \cot \varphi \operatorname{cosec} \varphi \sec \varphi) = 0$$

$$2 \sec \varphi \tan \varphi + \tfrac{1}{10} \tan \varphi \operatorname{cosec} \varphi = \tfrac{1}{10} \operatorname{cotan} \varphi \operatorname{cosec} \varphi$$

$$2 \sec \varphi \tan^2 \varphi + \tfrac{1}{10} \tan^2 \varphi \operatorname{cosec} \varphi = \tfrac{1}{10} \operatorname{cosec} \varphi$$

from which the cubic equation,

$$\tan^3 \varphi + \tfrac{1}{20} \tan^2 \varphi = \tfrac{1}{20}$$

This, being reduced, makes the tan. = .25701, or the angle 19° 25′, at which a pair of lock-gates should be situated, so as to have the greatest strength with a given section of timber.

Having obtained, in a manner I hope satisfactory, the angle of greatest strength for gates of straight timber, I conclude this part of my paper with a Table of the necessary dimensions of oak timber for lock-gates, varying from 6 to 20 feet in length, and from 8 to 20 feet in depth, which I believe are the limits of the dimensions of gates of this construction.

The first column in each division of the Table gives the amount of transverse strain produced by the pressure of water upon three feet depth of surface, at an angle of 19° 25′ ; and the second column the dimensions of square oak timber necessary to bear three times that strain.

To be Continued

Cultivation of the Prairies.

Continued from p. 204.

In England, paper is now made from the residuum of beets, after the saccharine matter is extracted. An application for a similar patent is now pending in the patent office. The sample of paper exhibited is very good, and the rapidity with which the paper is made, must materially reduce the price of this article. Many labor-saving machines are introduced to aid in the cultivation of new lands. In a few years, it is probable that ploughing on smooth lands may be effected by steam; and even now mowing and reaping are successfully done by horse-power.

Such are the profits of cultivation, that I would advise all who can, to improve some part of their lands. A small improvement will repay expenditures, and greatly enhance the value of the whole investment.

Three benefits may be expected:

1st. The crops will repay expenses, and yield great profit.

2d. The land cultivated, and the land adjoining, will be advanced several hundred per cent.

3d. If stock is put on the farm, the same may be numerically increased, and greatly enhanced in value, by improving the breed.

Either of these considerations is sufficient to justify cultivation, and guaranty a large return. I might mention the successful cultivation of hay in the west—from one and a half to two tons is a fair crop.—This can be cut and pressed without any labor-saving machines, for $2 per ton; and if the grass was cut by horse-power, the expense would be still less. The profits on one hundred heifers, at $5, might be easily supposed. Fifty breeding sows would probably give seven hundred pigs per annum; and by these means a large farm could be stocked, with little capital advanced.

Hay at New-Orleans varies from $20 to $50 per ton. An average, for the last three years, may be $30 The cost of floating down hay in flat boats, to New-Orleans, may be $8 per ton.

If, therefore, fifteen hundred to two thousand tons of hay could be cut on one thousand acres, would it not be a profitable crop?

There is a practice mentioned by Mr. Newell, and highly recommended by others of putting in hay seed without ploughing the ground. This is done by burning the prairie grass in the spring, and harrowing in the seed. The seed catches quick, and grows well. Blue grass, especially, succeeds, in this way, and the grass will sustain stock all winter without cutting any hay or fodder for them A large drove of horses were kept last winter at Indianapolis on blue grass, on the open fields, at the small expense of $1 per head per month.

From personal examination, I am convinced that ditching and hedging, as practised in Holland, England, and France, almost entirely, and now successfully adopted in Illinois, is cheaper than fencing by rails.

The general complaint of the earth crumbling by frost, is prevented by sowing blue grass seed on the sides. Mulberry trees might be raised on the slope of the ditch, with great profit. Indeed, such is the rapid growth of the mulberry in these rich prairie lands, that the purchase of this land at $1 25 an acre, and planted with these trees alone, would in a few years be highly valuable Such is the extent of the prairie, that wood land will always be valuable for timber. The wood land is also rich, and fine for cultivation; and if trees under certain diameter are cut, a fine grazing farm may be easily made, and the good timber preserved. Similar pastures are found in Kentucky; these yield $3 profit per acre, annually. It may be asked, how can non residents best cultivate their lands? I would remark, that it is customary to rent land (once broke and fenced) for one third of the crops delivered in the crib or barn. At this rent the tenant finds all.

I would advise to employ smart enterprising young men from the New-England States, to take the farm on shares. If the landlord should find a house, team, cart, and plough, and add some stock, he might then require one half the profits of the same. I would advise to allow, for fencing or ditching, a certain sum, and stipulate that the capital invested should be returned before profits were divided. A farmer could in this way earn for himself from $700 to $1,000 per annum, on a lease for five years.

The second year a mowing machine might be furnished, if one hundred acres were seeded down to tame grass. Mast for swine is found in great abundance, and the number of hogs could be easily increas-

ed te one thousand, by adding to the number of breeding sows.

Corn is easily raised, that it is found advantageous to turn the hogs into a field of this grain, without gathering it. It has long been the practice in the State of New-York, to raise oats and peas together, and turn in the swine to harvest the same when ripe. Experiments this summer in Connecticut, show a great profit in raising spring wheat and oats together, and feeding out the same to hogs. I have omitted to say, that good bituminous coal is found in the valley of the Wabash. The veins are from five to ten feet thick, and a large wagon load will supply one fire for a year. *Salt* also is manufactured in large quantities, and superior in quality to the Kenhawa salt.

Farmers in Illinois and Indiana are now successfully enclosing their lands by ditching, which has cost from fifty to seventy-five cents per rod.

The laws of the States of Indiana and Illinois, compel the owners of lands adjoining to pay one half of fencing, whenever they make use of, or derive any benefits from the fences of their neighbor. This lessens the expense of fencing one half.

If it be asked, what are the profits of cultivation? I answer, if the land is rented for five years, the profits accruing during this period, will repay the capital advanced in the commencement, with twenty-five per cent. interest per annum, and leave the farm worth $20 per acre at the expiration of the lease. Probably the profit will be much greater.

Yours, respectfully,
H. L. Ellsworth.

Lafayette, Nov. 1836.

Dear Sir—In consequence of the numerous inquiries by yourself, and others, relative to the improvement of wild lands, and especially prairies; the cost of cultivation; the quantity of crops; the market for the same, and the profits that may be expected, I have concluded to write you a general letter, to be used as might be thought proper. My knowledge is founded upon experience, having just completed a farm of eight hundred acres on the wild prairies.

The expense of breaking up the sod, is $2 25. This is a fixed price, and certain calculations may be made on it, wherever the land may be located. But a difference will exist in the cost of fencing, according to the distance the rails are carted. For the farm I have just fenced, the rails were hauled four miles. This distance will form the basis of my calculations. It is apparent that the cost of fencing will depend materially on the size and form of the area to be enclosed. An area of three hundred and twenty acres will cost much more than half of the amount required to fence six hundred and forty acres. The four sides of a half section are three miles; the two longest sides being one mile each, and the two shortest a half mile each. The four sides of a whole section, six hundred and forty acres, are four miles, requiring only *one quarter more fence* for *double* the quantity of land.

Twenty rails are allowed to a rod; this makes a "Virginia," or worm fence, eight rails high—the eighth rail (called a rider) being elevated twelve or eighteen inches from the seventh rail, and resting on crotches, (eight feet long,) crossing at each corner of the "worm." Rails of ordinary size, laid in this manner, make a durable and tight fence, over and through which no cattle or stock can pass.

First Estimate for improving six hundred and forty Acres.

Eour miles, or 1,280 rods, 20 rails to the rod, gives 25,600 rails.	
Add for enclosures, cribs, &c. 1,400 rails; total of rails is 27,000, which, at $3 50 per thousand, gives	$945 00
For one log house and well, and laying up fence,	200 00
For breaking up six hundred acres, (allowing remaining forty for bad spots, enclosures, &c.,) at $2 25,	1,350 00
Allow for contingencies,	30 00
	$2,525 00

Making not quite $4 per acre, costs, including buildings, &c.